SYSTEM AND METHOD FOR TREATING MICROORGANISMS WITHIN MOTOR VEHICLE HEATING, VENTILATION, AND AIR CONDITIONING UNITS

INVENTOR

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CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority of U.S. provisional application serial number 60/440,756 filed on January 15, 2003, which is fully and completely incorporated herein by reference.

FIELD OF THE INVENTION

[0002] This invention generally relates to heating, ventilation, and air conditioning (HVAC) systems within motor vehicles, and more specifically to a system and method for reducing the number of microorganisms in HVAC systems.

BACKGROUND OF THE INVENTION

[0003] Heating, ventilation, and air conditioning (HVAC) systems are a ubiquitous component of motor vehicles. Typically, HVAC systems comprise heating, refrigeration (or air conditioning), and air distribution components. Despite many technologic advances in the field, current HVAC systems still have considerable deficiencies. These systems are not well equipped to prevent the growth of microorganisms (including bacteria, fungi, molds, spores, viruses, and protozoa) within these systems. HVAC systems are also ill suited to prevent transmission of microorganisms from outside the vehicle into the passenger compartment. Finally, current HVAC systems are incapable of cleansing air from the passenger compartment of microorganisms that may be infectious.

[0004] The growth of fungus, bacteria, spores, molds, algae, protozoa and other microorganisms on the evaporator and other parts of an HVAC system in a

motor vehicle remains a significant problem. As air passes over the fins or coils of the evaporator, the air is both cooled and dehumidified. During the process, moisture collects on the evaporator and drains through the bottom of the case (through a drain pan for example). Once the vehicle is turned off, the evaporator warms up, and this warm, wet environment is highly conducive to fungal, mold, spore, bacterial, and protozoal growth. This problem of microorganism growth on the evaporator is especially common in areas of high humidity, where it is less likely that fluid on the evaporator will evaporate because of the high water content in the ambient air. And as evaporators incorporate more fins into their design and the distance between fins continues to decrease, the likelihood of trapping more moisture on the outside of the evaporator increases, as does the likelihood of increased microorganism growth.

[0005] The presence of microorganisms (most commonly bacteria, fungi, and protozoa) on the evaporator and other parts of the HVAC system is problematic for several reasons. First, these organisms produce foul odors that are transmitted into the passenger compartment. Second, the organisms themselves may be blown into the passenger compartment, leading to passenger infection (pneumonia, bronchitis) or other ailments. Allergic rhinitis and bronchial asthma in particular have both been shown to result from contamination of automobile air conditioners with microorganisms ("Respiratory allergies related to automobile air conditioners", New England Journal of Medicine, 1984, Vol. 311, No. 25, pp. 1619-1621). Legionella bacteria and various molds are particularly worrisome. Third, the growth of microorganisms as well as the organic matter they produce (biofilm) may coat the heat exchange surfaces, reducing heat transfer while simultaneously increasing the pressure drop across the system. Hence, the growth of microorganisms in HVAC systems remains a considerable problem in motor vehicles.

[0006] Several detergents and fungicides are available to kill organisms that

accumulate and grow on the evaporator. However, these chemicals are noxious and difficult to administer. A technician may need to wear a respirator while working with these chemicals. Moreover, gaining access to the evaporator can be time consuming and difficult, sometimes requiring extensive disassembly. In some cases, a hole must be drilled into the HVAC system, a hole that later has to be patched. Finally, since the chemicals eventually wear off, this procedure may have to be repeated at regular intervals, which is both inconvenient and expensive. Another approach is to install an after blow module (also known as an electronic evaporator dryer module), the purpose of which is to periodically operate the blower to dry off the evaporator once the vehicle is turned off. This is suboptimal since it requires energy use while the vehicle is turned off and does not kill the microorganisms. Moreover, both the blow module approach and application of chemicals merely prevent the growth of organisms within the HVAC system; they do not prevent transmission of infectious agents from entering from outside the car, nor do they cleanse the air from the passenger cabin of any potentially infectious agents.

[0007] Another problem with conventional motor vehicle HVAC systems is their inability to cleanse air from the passenger compartment of infectious pathogens. One might imagine several circumstances in which such a deficiency might lead passengers to become infected with an airborne pathogen, be it bacterial, viral, fungal (mold), spore, or other. One particularly worrisome organism is mycobacterium tuberculosis. Other organisms include various other bacteria and viruses that can lead to aerosolized transmission of the flu, colds, or other ailments. In the event that one person in a passenger cabin is infected (and perhaps is coughing or sneezing), the aerosolized infectious agent can be transmitted to other people in the closed cabin, leading to their infection. This is especially likely given the small space of the cabin. This becomes even more likely if the air is recirculated.

[0008] Finally, there is the potential problem of infectious agents from the outside environment entering the passenger cabin. These infectious agents include bacterial, viral, spore, fungal or other agents that may or may not be naturally present in the environment. With the increasing likelihood of the use of biological weapons, it would be of considerable benefit if automobiles and other motor vehicles were equipped with means of killing any infectious organisms that come in from the outside air. Such organisms might include but are not be limited to viruses such as small pox, bacteria such as anthrax, and various fungi/molds. Moreover, a system that inactivates airborne chemical compounds would also be of considerable interest. For example, a system that was able to inactivate a bioterrorism agent (including but not limited to nerve gas), allergen, or other noxious compound would be useful.

[0009] Current air filters in motor vehicle ventilation systems are ill suited to capture organisms below a certain size (<3 microns for example). As such, many infectious pathogens (including many bacteria and viruses) pass freely through the filters. Filters also have a tendency to become clogged, and need to be replaced periodically. Moreover, many motor vehicle owners tend to neglect recommended service actions; these filters may not always be replaced as required. Until they are replaced, clogged filters can lead to reduction in airflow.

[0010] Clearly there is a need for a system that solves at least one if not all of these three needs. The system should ideally prevent growth of microorganisms within the HVAC system (including on the evaporator), should eliminate infectious organisms that enter the HVAC system from the outside air, and should eliminate infectious organisms that enter the HVAC system from the passenger compartment (patient sneezing, coughing, breathing). Such a system should ideally be inexpensive, long-lasting, and not require an extensive redesign of current HVAC systems. Furthermore, the system should ideally be compact, and not add to the size of the current HVAC systems. Such a system would be

an important contribution to the art.

SUMMARY OF THE INVENTION

[0011] Systems involving the use of ultraviolet lighting and related elements to reduce the number of microorganisms within heating, ventilation, and air conditioning systems within motor vehicles are provided.

[0012] One non-limiting advantage of the present invention is that it provides a system and method that use ultraviolet light to reduce growth of microorganisms such as bacteria, fungi, spores, protozoa, and viruses within heating, ventilation, and air conditioning units within motor vehicles.

[0013] Another non-limiting advantage of the present invention is that it provides a system and method that use ultraviolet light to kill microorganisms such as bacteria, fungi, spores, protozoa, and viruses as they pass through heating, ventilation, and air conditioning units within motor vehicles.

[0014] According to one aspect of the present invention, an HVAC system is provided for a motor vehicle and includes at least one ultraviolet light source for treating microorganisms within the HVAC system.

[0015] According to another aspect of the present invention, a method for treating microorganisms within an HVAC system of a motor vehicle is provided and includes generating ultraviolet light within said HVAC system, effective to kill and prevent growth of microorganisms.

[0016] Additional advantages and features of the invention will appear from the following drawings and detailed description.

BRIEF DESCRIPTION OF THE FIGURES

[0017] Fig. 1 provides a schematic diagram of a first embodiment of the invention in which ultraviolet light sources are located within outside and in-car

air inlets, or within the drain pan of the HVAC system.

[0018] Fig. 2 provides a schematic diagram of a second embodiment of the invention in which an ultraviolet light source is located in the space between the air inlets and blower of the HVAC system.

[0019] Fig. 3 provides a schematic diagram of a third embodiment of the invention in which an ultraviolet light source is located between the blower and evaporator of the HVAC system.

[0020] Fig. 4 provides a schematic diagram of a fourth embodiment of the invention in which an ultraviolet light source is located near the evaporator of the HVAC system to provide light to the heat exchange surfaces of the evaporator.

[0021] Fig. 5 provides a schematic diagram of a fifth embodiment of the invention in which an ultraviolet light source is located between the evaporator and heater core of the HVAC system.

[0022] Fig. 6 provides a schematic diagram of a sixth embodiment of the invention in which an ultraviolet light source is located near the heater core of the HVAC system to provide light to the heat exchange surfaces of the heater core.

[0023] Fig. 7 provides a schematic diagram of a seventh embodiment of the invention in which an ultraviolet light source is located between the heater core and the outlets of the HVAC system.

[0024] Fig. 8 provides a schematic diagram of an eighth embodiment of the invention in which ultraviolet light sources are located within the outlets of the HVAC system.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0025] Systems involving the use of ultraviolet lighting and related elements to reduce the number of microorganisms within heating, ventilation, and air

conditioning systems within motor vehicles are provided. The term microorganism includes any organism (animal, plant, or other) of microscopic size. The term microorganism includes but is not limited to bacteria, fungi, molds, spores, protists, protozoa, algae, parasites, plants, viruses and prions. The term motor vehicle includes any self-propelled wheeled conveyance that does not run on rails. The term motor vehicle includes but is not limited to automobiles, minivans, trucks, buses, vans, sport utility vehicles, rickshaws, recreational vehicles (RV), motor homes, or any vehicle with a passenger compartment set on wheels that are powered by a motor. Moreover, vehicles that are capable of being pulled by another vehicle with a motor, such as trailers and other transport vehicles are also included. Furthermore, while the preferred embodiments of the invention are described in connection with motor vehicles, it should be appreciated that the invention may be implemented in any vehicle employing an HVAC system.

[0026] Before the subject invention is further described, it is to be understood that the invention is not limited to the particular embodiments described below, as variations of the particular embodiments may be made and still fall within the scope of the invention. It is also to be understood that the terminology employed is for the purpose of describing particular embodiments, and is not intended to be limiting.

[0027] It must also be noted that as used in this specification, the singular forms “a”, “an”, and “the” include plural reference unless the context clearly indicates otherwise. Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which this invention belongs.

[0028] As summarized above, the subject inventions are for use in reducing the number of and/or killing microorganisms such as bacteria, viruses, and fungi, spores, protozoa, and molds within HVAC systems within motor vehicles. An

important advantage of implementing such a system is that it reduces passenger exposure to microorganisms and their byproducts as well as improves heat exchange efficiency and/or minimizes pressure drop within the system. A common feature of all the subject inventions is the use of ultraviolet light as a convenient means of preventing growth and/or transmission of microorganisms within the HVAC system.

[0029] Ultraviolet light may be used to kill microorganisms including bacteria, fungus/molds, spores, and viruses. For example, ultraviolet light has been used to purify air in hospitals, clean rooms, food processing plants, and office buildings. Ultraviolet light with wavelengths 240-280 nm has traditionally been used for this purpose. In particular, ultraviolet light at or near 254 nm has been shown to be particularly effective in killing microorganisms due to the resonance of this wavelength within molecular structures within cells. Exposure to ultraviolet light leads to cellular and/or genetic (DNA) damage to the cells and subsequent death. Even a short term exposure (seconds) to ultraviolet light can lead to effective killing of microorganisms.

[0030] The present invention utilizes ultraviolet light within a motor vehicle HVAC system to substantially reduce or eliminate microorganisms within the system. Referring now to the figures, Fig. 1 illustrates a schematic diagram of a first embodiment of an HVAC system **50**, including a plurality of ultraviolet light sources, which are located within the outside and in-car air inlets and/or within the drain pan of the HVAC system. HVAC system **50** includes an outside air inlet **2** and an in-car air inlet **4**, which provide air from outside the car and air from inside the car (recirculated air), respectively, and ultraviolet light sources **3**A and **3**B, which are respectively disposed within inlets **2** and **4** and which provide ultraviolet light to the air inlets and surrounding conduits of the HVAC system. Positioning ultraviolet light sources **3**A, **3**B in these locations ensures that all air entering the system is subjected to ultraviolet light treatment. Additionally, HVAC

components including parts of the air ducts/conduits are also exposed to ultraviolet light to kill microorganisms that might accumulate or grow in these areas.

[0031] HVAC system **50** further includes a blower **8** for circulating and/or transferring air within the system, pre-blower portion or conduit **6**, post-blower portion or conduit **10**, an evaporator **12**, a drain pan **42**, which may be located below the evaporator **12**, post-evaporator portion or conduit **14**, a temperature door **16**, a heater core **18**, post-heater core portion or conduit **20**, air conditioning heater door **22**, floor air outlet **24**, defrost air outlet **26**, air conditioning defrost door **28** and panel air outlet **30**.

[0032] In the preferred embodiment, blower **8**, evaporator **12**, drain pan **42**, heater core **18**, and doors **16**, **22** and **28** may comprise conventional and commercially available HVAC components. Furthermore, portion or conduits **6**, **10**, **14**, and **20**, inlets **2** and **4**, and outlets **24**, **26** and **30** may be formed from conventional materials (e.g., plastic, metal and the like) and may be shaped in a known manner to conform to the contained components and structure of a motor vehicle in which the HVAC system **50** is disposed.

[0033] In the preferred embodiment, each ultraviolet light source 3A, 3B may comprise a single ultraviolet light bulb, or a plurality of light bulbs placed next to one another in a linear, circumferential or other pattern. The ultraviolet light bulb itself may be of any convenient shape, including but not limited to spherical, linear, circumferential, or spiral. Commercially available bulbs from a variety of suppliers may be used, or the bulbs may be custom-shaped to conform to the internal portions of the HVAC conduits. The bulbs used may emit any wavelength or wavelengths of ultraviolet light, or some combination of ultraviolet light and non-ultraviolet light. Non-ultraviolet light includes but is not limited to visible and infrared light. Preferably, the ultraviolet light will be in the UV-C spectrum, and most preferably there will be ultraviolet light with a wavelength at

or near 254nm, which has been shown to be particularly effective in killing microorganisms. In certain embodiments, bulb(s) which almost exclusively emit ultraviolet light above a certain wavelength (>200 nm or >220 nm for example) may be used, since they offer the additional benefit of producing less ozone.

[0034] The ultraviolet light sources **3**A, **3**B may be communicatively coupled to a conventional controller **32**, which is effective to selectively activate and deactivate the light sources **3**A, **3**B according to a predetermined control strategy. Particularly, the controller **32** may cause the light sources **3**A, **3**B to be selectively connected to and disconnected from a power supply **34**, which may comprise the motor vehicle's battery, the vehicle's alternator, an external generator, a solar generator, a fuel cell, or other suitable power supply, or any combination of the foregoing power sources.

[0035] The controller **32** may be a conventional microprocessor-based controller operating under stored program control. The controller **32** may be communicatively coupled to conventional vehicle components and accessories **36** (e.g., the ignition switch, air conditioning unit, fan, HVAC system and the like), switches **38** and/or sensors **40**, which may be monitored by controller **32** in order to control the operation of the light sources. For example, in certain embodiments, the ultraviolet light sources **3**A, **3**B may be activated or turned on whenever the engine is running. In other embodiments, the ultraviolet light sources **3**A, **3**B may be activated when the engine is turned off, and may remain on for a predetermined period of time (for example 1-100 minutes) or until the engine is turned on again. In still other embodiments, the ultraviolet light sources **3**A, **3**B may be turned on when the air conditioning unit is started, when the fan is started, or when the HVAC system is turned on. In other embodiments, the ultraviolet light sources **3**A, **3**B may be turned on when the air conditioning unit is turned off, when the fan is turned off, or when the HVAC system is turned off. In still other embodiments, the ultraviolet light sources **3**A, **3**B are always activated.

In other embodiments, the ultraviolet light sources **3**A, **3**B are turned on and off periodically using a timing mechanism or strategy. Furthermore, in other embodiments, the unit can be turned on or off manually by the user through a switch **38** or other mechanism that can be controlled from the passenger compartment. This mechanism may or may not include an automatic timer for activating or deactivating the ultraviolet light sources **3**A, **3**B after a predetermined period of time. In other embodiments, the ultraviolet light sources **3**A, **3**B are selectively activated and deactivated in an intermittent manner by a timer. Finally, there may be a switch or mechanism (e.g., switch **38**) that turns the light source off indefinitely.

[0036] The system may further comprise sensors **40** for sensing certain conditions and communicating signals to controller **32** for either turning the ultraviolet light sources **3**A, **3**B on or off, based on those conditions. Sensors **40** may be disposed inside or outside the HVAC system. These certain conditions that may be detected by the sensor include but are not limited to humidity, barometric pressure, and temperature. Other types of sensors include biologic sensors that are capable of detecting various organisms or their byproducts inside the passenger compartment, outside the vehicle, inside the HVAC system, etc. These organisms may include but are not limited to bacteria, molds, fungi, spores, protozoa, and viruses. Other types of sensors include chemical sensors that can detect various chemical compounds or materials, noxious or otherwise. In certain embodiments, the sensors **40** will feed information to the control system **32** which will selectively activate and deactivate ultraviolet light sources. Alternatively, the sensors **40** may be used to alert the user/passenger of a potential need to turn on or turn off the ultraviolet light source, and she may then do so manually by use of a switch **38**.

[0037] In some embodiments, there is an ultraviolet light source **3**C, which may be substantially identical in structure and operation to light sources **3**A and

3B, placed within, above or in relative close proximity to the drain pan **42** of the HVAC system to limit the growth of organisms in the drain pan and nearby areas.

[0038] In certain embodiments, there is a sensor in the passenger compartment or in a portion of the HVAC system distant from the light source and/or near the passenger compartment (in the outlets for example) that detects ultraviolet light, ozone, or other product or byproduct of this invention. If the sensor detects a particular compound or byproduct, it triggers an alarm (visual, audio or other). In some embodiments this alarm will cause the ultraviolet light system to turn off. Thus, the sensor helps to prevent transmission of ultraviolet light, ozone, or other compound into the passenger compartment.

[0039] In some embodiments, an ultraviolet light filtering mechanism may be placed between the ultraviolet light source and the passenger or other inner compartment that filters out any ultraviolet light that might otherwise reach the passenger compartment. In other embodiments, the presence of surfaces or materials that absorb or do not reflect ultraviolet light may be present in the ducts, portions or conduits between the ultraviolet light source and the passenger compartment. This serves to prevent transmission of ultraviolet light into the passenger or other inner compartment of the vehicle.

[0040] In certain embodiments, the inner surfaces of some if not all components of the HVAC system are coated with or are made of substances that reflect ultraviolet light. The use of such reflective materials/coating is aimed at providing continued exposure to reflected ultraviolet light at locations distant from the light source. This continued exposure to ultraviolet light makes it more likely that organisms in the air will be killed during their passage time in the HVAC system. The materials may include any conventional and commercially available materials that reflect ultraviolet light. These include but are not limited to magnesium oxide, polished aluminum sheet, white plaster, aluminum paint, chromium, nickel and stainless steel. By using such reflective surfaces, it is

possible to prevent organism growth everywhere in the HVAC system. Moreover, because reflected ultraviolet light increases killing efficiency, fewer light sources may be required to achieve a desired kill rate.

[0041] In some embodiments, there may be a device located within the HVAC system that reduces the amount of ozone, if any, which may be produced during the ultraviolet light generation process.

[0042] In some embodiments, there may be one or more conventional air filtering devices present within the HVAC system. The one or more filtering devices may be disposed and/or incorporated within any of the conduits or components of the HVAC system. Such air filtering devices would be useful in reducing the amount of microorganisms or debris in the air within the HVAC system. Alternatively, the filter(s) (e.g., containing activated carbon or other compounds) could serve to remove foul odors in the air. The combination of the filter(s) and the ultraviolet light exposure would provide a complementary solution to both remove/kill microorganisms as well as their odors.

[0043] In some embodiments, when the ultraviolet light source is turned on, the HVAC unit reverts to "recirculation mode" in which the outside air inlet **2** is closed and the recirculated air inlet **4** is open. As the air is recirculating, microorganisms are exposed to ultraviolet light multiple times as they pass through the system, increasing the likelihood that they will be killed.

[0044] Fig. 2 provides a schematic diagram of a second embodiment of an HVAC system **60** in which an ultraviolet light source **7** is located in pre-blower portion or conduit **6**, which is defined as the space between air inlets **2** and **4** and blower **8**. Ultraviolet light source **7** may be substantially identical in structure and operation to light sources **3**A and **3**B. Positioning ultraviolet light in this location ensures that all air entering the system is subjected to ultraviolet light prior to reaching blower **8**. Additionally, HVAC components including parts of the blower

and the air ducts/conduits are also exposed to ultraviolet light. This second embodiment is substantially identical in structure and function as HVAC system **50** shown in Fig. 1, with like elements bearing identical reference numerals.

[0045] Fig. 3 provides a schematic diagram of a third embodiment of an HVAC system **70** in which an ultraviolet light source **11** is located in post-blower portion or conduit **10**, which is defined as the space between blower **8** and evaporator **12**. Ultraviolet light source **11** may be substantially identical in structure and operation to light sources **3**A and **3**B. Positioning an ultraviolet light source in this location ensures that all air propelled into post-blower portion or conduit **10** is subjected to ultraviolet light. Additionally, HVAC components including parts of the blower, evaporator, and air ducts/conduits are also exposed to ultraviolet light. This third embodiment is substantially identical in structure and function as HVAC system **50** shown in Fig. 1, with like elements bearing identical reference numerals.

[0046] Fig. 4 provides a schematic diagram of a fourth embodiment of an HVAC system **80** in which an ultraviolet light source **13** is located in close proximity to evaporator **12**, allowing ultraviolet light exposure to parts of the evaporator (including heat exchange surfaces) and surrounding components such as the drain pan **42**, etc. Ultraviolet light source **13** may be substantially identical in structure and operation to light sources **3**A and **3**B. Positioning an ultraviolet light source in this location ensures that air propelled through evaporator **12** is subjected to ultraviolet light treatment. Additionally, HVAC components including parts of evaporator **12** and air ducts/conduits are also exposed to ultraviolet light. By exposing the heat exchange surfaces to ultraviolet light, the surfaces will be less prone to microorganism/biofilm buildup with a corresponding increase in heat exchange efficiency. This fourth embodiment is substantially identical in structure and function as HVAC system **50** shown in Fig. 1, with like elements bearing identical reference numerals.

[0047] Fig. 5 provides a schematic diagram of a fifth embodiment of an HVAC system **90** in which an ultraviolet light source **15** is located in post-evaporator portion or conduit **14**, which is defined as the space between evaporator **12** and heater core **18**. Ultraviolet light source **15** may be substantially identical in structure and operation to light sources **3**A and **3**B. Positioning an ultraviolet light source in this location ensures that all air propelled into the post-evaporator portion or conduit **14** is exposed to ultraviolet light. Additionally, HVAC components including parts of evaporator **12** and air ducts/conduits are also exposed to ultraviolet light. This fifth embodiment is substantially identical in structure and function as HVAC system **50** shown in Fig. 1, with like elements bearing identical reference numerals.

[0048] Fig. 6 provides a schematic diagram of a sixth embodiment of an HVAC system **100** in which ultraviolet light source **19** is located in close proximity to heater core **18**, allowing ultraviolet light exposure to parts of the heater core (including heat exchange surfaces) and surrounding components. Ultraviolet light source **19** may be substantially identical in structure and operation to light sources **3**A and **3**B. Positioning an ultraviolet light source in this location ensures that air propelled through heater core **18** is subjected to ultraviolet light treatment. Additionally, HVAC components including parts of heater core **18**, air ducts/conduits, and temperature door **16** are also exposed to ultraviolet light. By exposing the heat exchange surfaces to ultraviolet light, it is expected that the surfaces will be less prone to microorganism/biofilm buildup with a corresponding increase in heat exchange efficiency. This sixth embodiment is substantially identical in structure and function as HVAC system **50** shown in Fig. 1, with like elements bearing identical reference numerals.

[0049] Fig. 7 provides a schematic diagram of a seventh embodiment of an HVAC system **110** in which ultraviolet light source **21** is operatively disposed in the post-heater core portion or conduit **20**, which is defined as the space

between heater core **18** and the outlets downstream. Ultraviolet light source **21** may be substantially identical in structure and operation to light sources **3**A and **3**B. Positioning an ultraviolet light source in this location ensures that all air propelled into post-heater core portion or conduit **20** is exposed to ultraviolet light. Additionally, HVAC components including parts of heater core **18** and the air ducts/conduits are also exposed to ultraviolet light. This seventh embodiment is substantially identical in structure and function as HVAC system **50** shown in Fig. 1, with like elements bearing identical reference numerals.

[0050] Fig. 8 provides a schematic diagram of an eighth embodiment of an HVAC system **120** in which ultraviolet light sources are located in one or more air outlets. The diagram in Fig. 8 illustrates three ultraviolet light sources **23**A, **23**B, and **23**C, which are respectively and operatively disposed in floor air outlet **24**, defrost air outlet **26**, and panel air outlet **30**. All three of these outlets provide air into the passenger compartment albeit in different locations. Ultraviolet light sources **23**A, **23**B, and **23**C provide ultraviolet light into their respective air outlets and onto surrounding portions of the HVAC system including A/C heater door **22** and A/C defrost door **28**. Ultraviolet light sources **23**A, **23**B and **23**C may be substantially identical in structure and operation to light sources **3**A and **3**B. Positioning ultraviolet light sources in these locations ensures that all air exiting the system is subjected to ultraviolet light treatment. Additionally, HVAC components including parts of the air ducts/conduits are also exposed to ultraviolet light. This eighth embodiment is substantially identical in structure and function as HVAC system **50** shown in Fig. 1, with like elements bearing identical reference numerals.

[0051] Finally, in other embodiments, ultraviolet light sources may be placed in multiple locations, combining elements from two or more of the previously detailed embodiments. For example, ultraviolet light sources may be placed in both pre-blower portion or conduit **6** and post-blower portion or conduit **10**. Any

combination of locations that have been described previously fall within the scope and spirit of this application.

[0052] Hence, it is evident that the subject devices provide a number of important advantages over prior art devices. The use of ultraviolet light in HVAC systems in motor vehicles offers the benefit of killing microorganisms (bacteria, viruses, molds, spores, protozoa, and fungi) that enter from the outside air, preventing passengers within the passenger compartment from being exposed to these potentially harmful pathogens. Moreover, ultraviolet light exposure serves to kill microorganisms that are already present in the passenger compartment (for example, by an already infected passenger who might be coughing or sneezing). Finally, ultraviolet light exposure to components within the HVAC system (including the evaporator) offers the benefit of reducing microorganism growth on the heat exchange surfaces, therefore improving the efficiency of the system. Simultaneously, such a reduction in microorganism growth is expected to reduce the incidence of respiratory ailments such as allergic rhinitis and bronchial asthma since these microorganisms are not blown into the passenger compartment. Moreover, killing microorganisms also prevents transmission of foul odors. As such, the subject invention represents a significant contribution to the art.

[0053] Although the foregoing invention has been described in some detail by way of illustration and example for purposes of clarity of understanding, it is readily apparent to those of ordinary skill in the art in light of the teachings of this invention that certain changes and modifications may be made thereto without departing from the spirit and scope of the invention.